CHROMOSOME NUMBER IN ACER AND STAPHYLEA

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With plate 81

INTRODUCTION

ACCORDING TO HUTCHINSON (1926) *Acer* is a large genus distributed widely throughout the northern temperate zone in North America, Europe, western Asia, China, Japan, and is found also in northern Africa. This large group of approximately 115 species is divided into at least 14 subgroups. Eight of these subgroups are represented in this study by 13 species and varieties. Two more subgroups, represented by one species in each, have been studied by Taylor (1920). In all, 10 of the 14 subgroups and 19 species and varieties have been studied by various workers, affording a rather broad basis for conclusions.

Closely allied to the Aceraceae are the Staphyleaceae. In the genus *Staphylea* two species have been previously studied (Mottier, 1914, Winge, 1917). These two have been re-examined and two additional species studied in the present work.

MATERIALS

In the spring of 1933, branches bearing male flowers of *Acer* and *Staphylea* were brought into the laboratory and examined for reduction divisions in the pollen mother-cells and for microscope divisions. The reduction divisions in *Acer* apparently occur very early, when flower buds and anthers are extremely small. A similar condition is true of *Staphylea*. Out of a large amount of material, satisfactory stages were found in only 13 species and varieties of *Acer* and 4 species of *Staphylea*. All material examined for chromosome counts was studied from aceto-carmine smears prepared according to Belling's formula (Belling 1926).

In addition to chromosome counts, preparations of the fully developed pollen were made and examined for pollen sterility counts. These counts were made on 53 species and varieties of *Acer*. All material was gathered in the Arnold Arboretum.

RESULTS

The chromosome counts and the pollen sterility counts on the species of *Acer* examined cytologically are summarized in Table I. For com-

TABLE I.

Group	Species	n	2n	Sterility of pollen	Author	Distribution (According to Rehder 1927)
I. Platanoidea	platanoides L.	13	26	1%	Meurman, 1933	Europe and Caucasus
	Miyabei Maxim.	13		5%		Japan
II. Campestria	campestre L.	13		1-3%		Europe; Western Asia
III. Saccharina	saccharum Marsh.	13		5%	Taylor, 1920	East Canada, south to Ala., Ga., Miss.
IV. Spicata	pseudoplatanus L.	26	52	1%	Taylor, 1920	Europe, West Asia
	pseudoplatanus var. erythrocarpum Carr.	26		1-2%		
V. Palmata	circinatum Pursh	13		10-50%		Brit. Columb. to Calif.
	palmatum Thunb. var. intermedium	13		20%		
	pseudo-sieboldianum Komar.	13		10%		Manchuria to Korea
VIII. Indivisa	carpinifolium Sieb. & Zucc.		52		Taylor, 1920	Japan
IX. Macrantha	rufinerve Sieb. & Zucc.	13		1-5%		Japan
	Tschonoskii Maxim.	13		2%		Japan
XII. Rubra	rubrum L.	40			Darling, 1912	Newfoundland to Fla., west to Minn. and Texas
	"	36			Taylor, 1920; Mottier, 1914	
	"	±50	88-94		Taylor, 1920	
	"	68-75			" "	
	"	52		5%		
	saccharinum L.	26	52 & ±91		Taylor, 1920	Que. to Fla., west to Minn. & Okla. Blooms very late in fall
XIII. Trifoliata	nikoense Maxim.	13				Japan, Central China
	griseum Pax.	13		1-5%		West China
	mandshuricum Maxim.	13				Manchuria, Korea
XIV. Negundo	Negundo L.	13		20%	Taylor, 1920; Darling, 1909; Sinoto, 1929	New England, southward
	Negundo var. interius Sarg.	13		25%		Alberta & Saskatoon to Ariz. & New Mex.

pleteness, this table also includes counts made by other workers and a brief indication of the geographic distribution of these species, according to Rehder (1927). Without exception, the haploid chromosome numbers found in this study were 13 or multiples of 13.

Of *Staphylea,* four species were examined. The results are summarized in Table II.

TABLE II.

Species	n	Distribution
Staphylea bumalda DC	13	Japan
" pinnata L.	13	Central and southern Europe
" colchica Stev.	26	Caucasus
" trifolia L.	39	Eastern Canada and U. S.

Here, as in *Acer,* the haploid number is either 13 or a multiple of 13.

DISCUSSION

Of the 19 species and varieties of *Acer* which have been examined cytologically, 14 are diploids, with n = 13. Four are tetraploids, with n = 26; one of these, *A. carpinifolium* has had only its somatic number studied (Taylor, 1920). *A. rubrum* is an octoploid, with n = 52. The Maples, then, have 13 as a basic number and are, for the most part, diploids, but a polyploid series does exist.

Differing counts have been made by other workers. Cardiff (1906) found n = 11 in *A. platanoides,* a count corroborated by Taylor (1920) who found, however, 2n = 26 in somatic counts on seedlings of this species. Meurman (1933) finds n = 13 in this species, as did Darling (1923). One seedling which the former examined proved to be a triploid, 2n = 39, which he regards as either an autotriploid, or a hybrid between a diploid and a tetraploid (loc. cit. p. 159).

In *A. rubrum,* for which n = 52 was found, four other counts have been made by Darling (1912), Mottier (1914) and Taylor (1920). The last named worker, in one instance, made a meiotic count of n = ±50, which approximates the count made in the present study.

The varying counts made on *A. rubrum* make plausible Taylor's (1920) suggestion of races within this species, possessing different chromosome numbers. Such a condition is known in other species, such as *Musa sapientium* L. (Tischler, 1910, 1928).

The count of n = 13 in *A. Negundo* has been made by three different workers, Darling (1909), Taylor (1920) and Sinoto (1929), although Mottier (1914) found n = 12 or 14.

The chromosomes in *Acer* are quite small in size. In shape they have been described as "elongated" (Mottier, 1914), "ovoid" (Taylor, 1920), and "irregularly polygonal" by Sinoto (1929) who denies the accuracy of the first two descriptions. All three characterizations, as a matter of fact, are correct, as can be seen from the accompanying figures. Elongated chromosomes are clearly shown in Fig. 6, and both ovoid and irregularly polygonal types in Figs. 2, 3, and 5. The apparent shape undoubtedly varies with the angle at which the mitotic figure is oriented with regard to the observer.

All the forms studied showed complete formation of bivalents. Even in polyploids like *A. rubrum,* no univalent or multivalent formations were seen. Meurman (1933) found a similar completeness of pairing in *A. platanoides,* as did Sinoto (1929) in *A. Negundo.* This situation is probably due to the fact that with a low chiasma frequency, there is little chance for the formation of multivalents. At metaphase I in the octoploids *A. rubrum* most of the bivalents have one chiasma and are in the form of rods; there are few if any rings. Meurman (loc. cit. Figs. 13 and 17) shows this to be true of *A. platanoides,* and the accompanying Figs. 1 and 7 of 1st metaphases, show this is the case in *A. Miyabei,* and *A. pseudoplatanus* var. *erythrocarpum.* From this it is apparent that the chiasma frequency is probably 1, although the occasional presence of a ring would raise it slightly above 1.

As a result of the regularly-formed bivalents, the chromosomes can be distributed regularly to the poles, even in polyploids like *A. rubrum.*

The phenomenon of secondary pairing noted by Meurman (1933) in *A. platanoides* is present in the species included in the present study. It is especially well shown in Figs. 6 and 8. Meurman (loc. cit. pp. 160 and 162) also found that 2 large pairs of bivalents showed secondary pairing at both the 1st and 2nd metaphases, but found no such pairing between other bivalents.

It was not found practicable to include a study of somatic chromosomes, but both Taylor (1920) and Meurman (1933) have published some details on this point. Taylor noted that the longest somatic chromosome studied was about 3 microns long, and the smallest, 1 micron long, with diameters of from 1/3 to 2/3 microns. Meurman found in the somatic chromosomes of *A. platanoides* lengths from 0.8—22 microns. Both writers, too, note the existence of regions of doubling of chromosome numbers in the root tips.

Pollen sterility counts were made on 53 species and varieties. Most of them showed a high percentage of good pollen. The species and varieties showing more than 80% good pollen were as follows: *A.*

platanoides L. and its varieties *cucullatum* Nichols, *Schwedleri* K. Koch, *Stollii* Spaeth, *dilaceratum* Dieck, *palmatifidum* Tausch, *columnare* Carr., *nanum* Nichols., *A. Miyabei* Maxim., *A. truncatum* Bge., *A. pictum* Thunb., *A. campestre* L., and its varieties *compactum* Schwerin and *postelense* Lauche, *A. saccharum* Marsh., *A. grandidentatum* Nutt., *A. pseudoplatanus* L. and its variety *erythrocarpum* Carr., *A. Heldreichii* Orph. var. *macropterum* Vis., *A. Trautvetteri* Medwed., *A. ginnala* Maxim. and its var. *aidzuense* Franch., *A. tataricum* L., *A. palmatum* Thunb. and its varieties *atropurpureum* Nichols., *sanguineum* Lem., *septemlobum* K. Koch, *intermedium* Schwerin, *elegans* Koidz., *Hessei* Schwer., *sinuatum* Schwer. and *laciniatum* Schwer., *A. Sieboldianum* Miq., *A. pseudo-Sieboldianum* Komar. and its variety *ambiguum* Nakai, *A. pennsylvanicum* L., *A. rufinerve* Sieb. & Zucc., *A. Tschonoskii* Maxim., *A. argutum* Maxim., *A. rubrum* L. and its variety *glaucum* Marsh., *A. griseum* Pax and *A. Negundo* L. and its varieties *pruinosum* Schwer. and *texanum* Pax.

Certain species display a high percentage of poor pollen, as follows:

A. Mayrii Schwerin	50%	bad
A. zoeschense Pax	50%	"
A. spicatum Lam.	55%	"
A. circatum Pursh	50%	"
A. tegmentosum Maxim.	100%	"
A. barbinerve Maxim.	90%	"
A. Negundo L., var. *interius* Sarg.	25%	"
A. Negundo, var. *nanum* Dieck.	50%	"

Such high percentages of pollen sterility, as contrasted with the lower figures for the others studied, indicate a possible hybrid origin of these species or structural hybridity. In the case of one species, *A. zoeschense*, Rehder (1926) indicates that it may be a hybrid between *A. campestre* L. and *A. Lobelii* Ten.

Little data on hybridization appear available. Rehder lists about 15 species hybrids, but they are usually between species in the same subgroup or in closely related subgroups. The widest cross noted was that between *A. opalus* Mill., var. *obtusatum* Henry in the *Campestria*, and *A. pennsylvanicum* L. in the group *Macrantha*.

Information on grafting supplied by William H. Judd of the Arnold Arboretum, indicates that *A. griseum* Pax and *A. parviflorum* Franch. & Sav. have not been used successfully in grafting with other species.

Ordinarily, too, a species can be used as stock or scion only with species closely related to it. Mr. Judd has found this to be particularly true of *A. platanoides*.

Chromosome conditions in *Staphylea* present a close parallel with those in *Acer*. The basic number is 13, but a tetraploid, *S. colchica*, n = 26, and a hexaploid, *S. trifolia*, n = 39, are found. In *S. pinnata* Winge (1917) found n = 12, but noted n = 13 in one cell. Mottier (1914) found n = ±36 in *S. trifolia*. Although the chromosomes are much larger than those of *Acer* it is difficult to determine their shape from polar views of meiotic metaphases. Like *Acer*, too, they appear to have a low chiasma frequency, and separation is quite regular. The secondary pairing is clearly shown in Figs. 10 & 11. As in *Acer*, this secondary pairing is between 2 bivalent chromosomes, and often makes an accurate count quite difficult.

The data thus presented show that in two genera belonging to different families there are identical basic chromosome numbers together with a similarity in polyploid series, secondary pairing, and low chiasma frequencies.

In *Acer* there is found a great differentiation of species in a highly polymorphic genus. Yet this process of species differentiation has taken place with no change in the basic chromosome number of the genus. Although only 1/6 of the known species of *Acer* have been studied, their distribution throughout the subgroups of the genus is sufficiently wide to make this statement reasonable. What is true of a genus is apparently true also of families. Despite a clear relationship, the Staphyleaceae are admittedly different from the Aceraceae morphologically, but the type genus, *Staphylea*, shows the same chromosome set-up and the same general behavior, even to secondary pairing, which is found in *Acer*. It is true that there are differences in chromosome size between the two genera, but this is probably of no great significance. Such differences in chromosome size often exist between species within a genus or between varieties of the same species. Considered with other similarities, the common chromosome number and behavior may well indicate a common origin for these two closely related genera.

SUMMARY

1. Chromosome counts were made on the meiotic stages of thirteen species and varieties of *Acer* and four species of *Staphylea*. Thirteen was found to be the basic haploid number in each genus.

2. These counts, with those given by other workers show that most of the species are diploids. A polyploid series, however, is found in each genus.

3. The chromosomes of *Acer* are small, have a low chiasma frequency, behave regularly since no univalents or multivalents are present, and exhibit secondary pairing.

4. The chromosomes of *Staphylea* are larger than those of *Acer,* but show the same low chiasma frequency, regularity of behavior, and second pairing.

5. Pollen sterility counts were made on 53 species and varieties of *Acer.* Forty-five showed more than 80% good pollen. The remaining eight showed from 25-100% sterility.

6. Evidence from hybridization and grafting is briefly considered.

7. It is concluded that the cytological details afford evidence of a common origin for the Aceraceae and Staphyleaceae.

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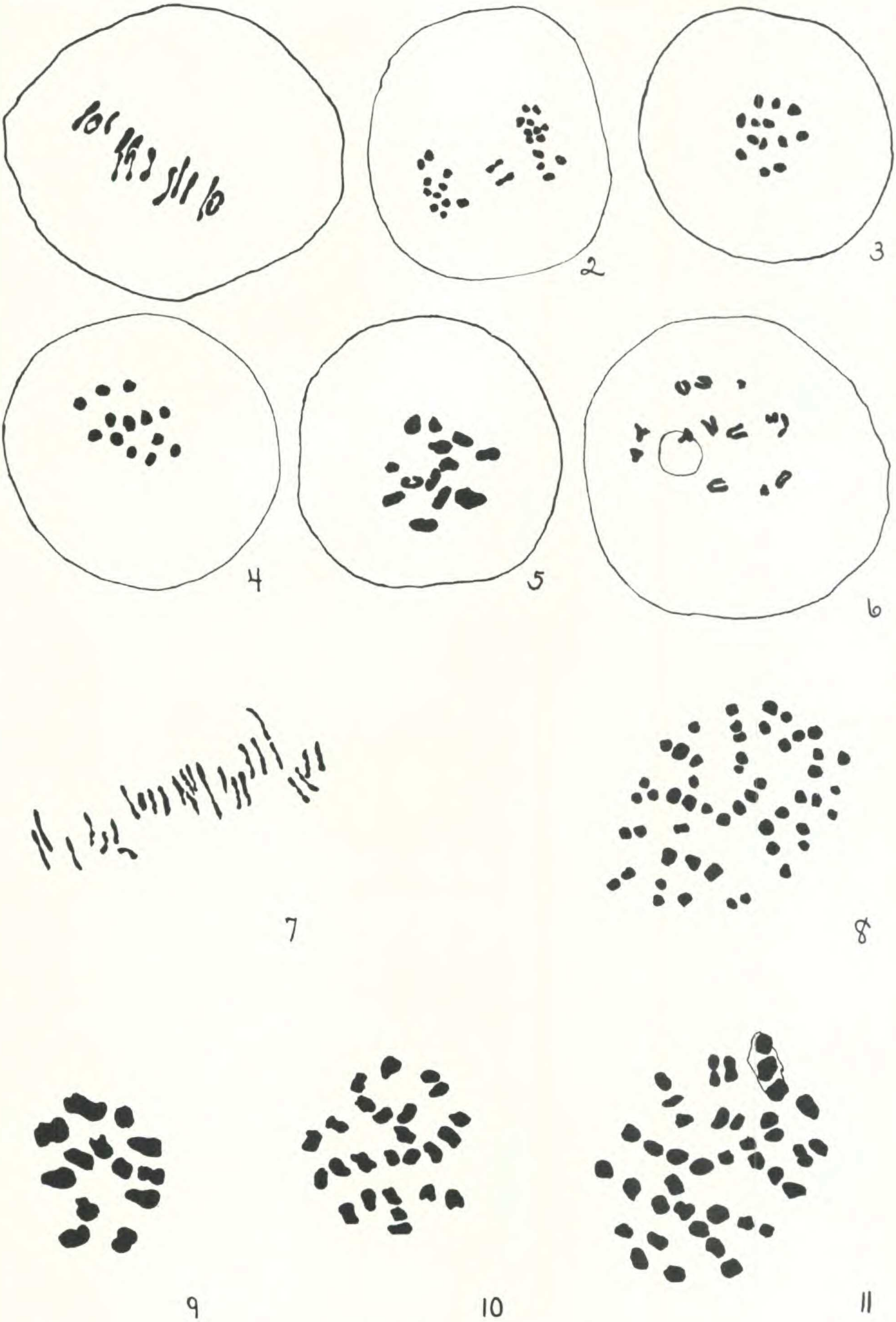
LITERATURE CITED

1. Belling, John (1926). The iron-aceto-carmine method of fixing and staining chromosomes. (Biol. Bull. **50**:160–161.)
2. Cardiff, J. D. (1906). A study of synapsis and reduction. (Bull. Torrey Bot. Club, **33**:271–306.)
3. Darling, C. A. (1909). Sex in dioecious plants. (Bull. Torrey Bot. Club, **36**:177–199.)
4. ——— (1912). Mitosis in living cells. (Bull. Torrey Bot. Club, **39**:407–409.)
5. ——— (1923). Chromosome behavior in Acer platanoides L. (Amer. Jour. Bot. **10**:450–457.)
6. Hutchinson, J. (1926). Families of flowering plants. I. Dicotyledons. pp. 328. (Macmillan, New York.)
7. Meurman, O. (1933). Chromosome morphology, somatic doubling and secondary association in Acer platanoides L. (Hereditas, **18**:145–173.)
8. Mottier, D. M. (1914). Mitosis in the pollen-mother-cells of Acer negundo L. and Staphylea trifolia L. (Ann. Bot. **28**:115–133.)
9. Rehder, Alfred (1927). Manual of cultivated trees and shrubs. pp. 930. (Macmillan, New York.)
10. Sinoto, Y. (1929). Chromosome studies in some dioecious plants with especial reference to the allosomes. (Cytologia, **1**:109–191.)
11. Taylor, W. R. (1920). A morphological and cytological study of reproduction in the genus Acer. (Contrib. Bot. Lab. Univ. Penn. **4**:271–300.)



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